Draft Spanaway Lake Management Options Screening								
OPTION		Summary Description	Potential Problem(s) Addressed		Priority for Additional Evaluation			Comments
			Cyano-bacteria	Fecal Coliform	Low	Med	High	
Watershed Measures								
1	Stormwater treatment/removal	Treat or infiltrate runoff prior to discharge to lake.	x	x			x	Relatively small source but still a good idea to control. Potential measures could include constructed wetlands and low impact development (LID) retrofits where feasible.
2	Sewering	Extend sewer lines to septic system areas, require connection to sewer. Could focus on areas closest to lake.	x	x		?	?	Very costly. Could take many years for P concentrations in groundwater inflow to drop to pre-developed levels.
3	Septic system improvements	Retrofit systems to improve treatment (e.g., new pressurized drainfield, sand filter). Could focus on systems close to lake.	x	x		?	?	Costly to very costly depending on the scale. Less P load reduction than sewering. Could take many years to reduce P loading in groudnwater entering lake.
4	Waterfowl management	Use harassment (e.g., dogs) and/or shoreline landscaping to discourage waterfowl from using beaches, play fields, etc.	x	x			x	Probably a minor P source but could be important bacteria source in parts of the lake that attract a lot of waterfowl.
5	Public education	Encourage people to landscape shorelines to deter waterfowl, minimize P fertilizer use, discourage feeding of waterfowl.	x	x			x	Focus on landscaping practices, waterfowl management. Probably minor benefits for cyanobacteria, but could reduce fecal bacteria in lake areas with heavy bird use.
6	Landscaping	Improve landscaping practices to reduce runoff of sediment and nutrients.	x	x			x	Focus on shoreline areas where stormwater runoff can flow directly into lake.
In-Lake Measures								
1	Hypolimnetic oxygenation	Introduce oxygen to help create aerobic conditions near lake bed and thereby reduce P release from sediment. Likely would form aerobic crust on upper sediment that would isolate underlying anoxic sediments and limit nutrient release.	x				x	Would require pipes, pumps, etc. System would need to be run when lake is stratified. Additional evaluation would be needed to estimate performance and cost.
1.1	Vigorous Epilimnetic Mixing	Adds air to lake and also causes slow vertical mixing that disrupt blue-green algae. Method is relatively new but has worked well at Cherry Creek Reservoir near Denver and in Cardiff Bay Barrage in UK (~20 km of air lines with attached diffusers on bottom).	x		x			Could be implemented to augment hypolimnetic oxygenation in the future. Additional evaluation would be needed to estimate performance and cost.
2	Circulation and destratification	Use air or water to keep water in motion and prevent or break stratification.	x		x			Uncertain benefits, could have unintended consequences.
3	Dilution and flushing	Add relatively clean water to lower P and FC concentrations and decrease hydraulic residence time.	x	x	x			Infeasible. Would need large source of water with low [P].
4	Drawdown	Lower water level to oxidize, desiccate, and/or compact sediments.	x		x			May not provide much benefit. No existing infrastructure to drawdown or convey.
5	Dredging	Remove P-rich sediment from lake bed using clamshell or hydraulic dredge. Dewater spoils and transport them to appropriate disposal area(s).	x		x			Very expensive, especially if the dredge spoils must be shipped away for disposal. Would need to collect sediment cores to estimate depth/volume to be removed, and perform additional monitoring (e.g., benthic flux chambers, hypolimnion sampling) to estimate P reductions. Dredging might need to be repeated in future if external P sources are not controlled.
6	Light-Limiting Dyes and Surface Covers	Limit light to suppress aquatic plant growth.	x		x			Not recommended. Would interfere with lake uses.
6.1	Dyes	Limits light penetration in order to inhibit algal growth.	x		x			Not feasible or appropriate for a lake of this type.
6.2	Surface Covers	Opaque material applied to water surface.	x		x			Infeasible for a lake of this type.
7	Mechanical Vegetation Control (harvesting, hydroraking)	Remove aquatic plants (and the P in their tissues).	x		x			Rooted aquatic plants play an important ecological role in balancing the dominance of microscopic algae. Would need to consider timing and scope. Could have unintended consequences (e.g., other species could become dominant). Not recommended at this time.
8	Selective Withdrawal	Withdraw hypolimnion water that contains elevated P.	x			x		Locate intake for golf course irrigation in the hypolimnion to remove P-rich water and apply to golf course.
9	Algaecides	Apply chemicals to lake to kill algae.	x			x		Homeowners have been applying herbicides for years. Could be an option in conjunction with long-term nutrient source controls if applied very conservatively only as-needed. Reducing algae could increase light penetration and rooted plant growth.
9.1	Forms of copper	Toxic to algae.	x		x			Ecology generally does not allow copper treatment. Short-term benefit.
9.2	Forms of endothall	Amine formulation (e.g., Hydrothol 191) can be used at low concentrations to control algae.	x			x		Short-term benefit; may require several treatments per season. Hydrothol is effective on algae but is acutely toxic to fish.
9.3	Forms of diquat	Fast-acting, non-selective contact herbicide applied as a liquid.	x		x			Most commonly used as a broad-spectrum herbicide for control of rooted aquatic plants, but applicators have reported that it appears to kill or suppress some species of algae. Short-term benefits.
9.4	Sodium carbonate peroxyhydrate	Fast-acting algaecide.	x			x		Acts as an oxidizing agent to kill algae. Active for only a short time in the water column.
10	Phosphorus Precipitation and Inactivation	Apply buffered alum (or similar chemical) to bind with and remove soluble P from the lake. Phosphorus precipitation focuses on shorter-term removal of P from the water column, while inactivation aims for longer-term control settling the control compound on the lake bottom to inactivate P released from sediments.	x				x	Uncertain how long treatment will last due to rooted plants and continuing P loads from Coffee Creek and groundwater. Reducing algae populations could increase growth of rooted plants.
10.1	Whole lake treatment	Apply to entire lake. Could apply increased dose to coat sediment in areas of suspected groundwater inflow.	x				x	Uncertain how long treatment will last due to rooted plants, Coffee Creek and groundwater P loads.

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10.2	Alum emitter(s)	Install alum emitters at key inflow points (e.g., Coffee Creek, known groundwater discharge zones) to remove P as it enters the lake. Alum will also help remove fecal coliform.	x	x			x	Could help reduce P in the lake water column. Could prolong benefits of whole lake treatment. Maybe hard to delineate GW discharge areas. Maybe impractical if GW discharge occurs at low rate over large area.
13	Selective nutrient addition	Add nutrients to change composition of algal community.	x		x			Hard to predict outcomes, could have unintended consequences.
14	Enhanced grazing	Encourage species that eat algae.	x		x			Lake ecology is complex so it is hard to predict outcomes. Could have unintended consequences.
14.1	Herbivorous fish	Stock fish that each algae.	x		x			Not recommended. Hard to predict outcomes, could have unintended consequences.
14.2	Herbivorous zooplankton	Encourage zooplankton that graze on algae.	x		x			Hard to predict outcomes, could have unintended consequences. Better to encourage indirectly by fostering a healthy and diverse native aquatic plant community.
15	Bottom-feeding fish removal	Remove bottom-feeding fish that each water weeds and stir up sediment.	x		x			Benefits are unclear. Hard to predict outcomes, could have unintended consequences.
16	Fungal/bacterial/viral pathogens	Add inoculum to initiate attack on algal cells.	x		x			Hard to predict outcomes, could have unintended consequences.
17	Competition and allelopathy	Add plants that outcompete or excrete substance that inhibit cyanobacteria.	x		x			Hard to predict outcomes, could have unintended consequences.
17.1	Plantings for nutrient contr	Plant species that can outcompete algae for nutrients.	x		x			Hard to predict outcomes, could have unintended consequences. Algae typically out-compete rooted plants for nutrients.
17.2	Plantings for light control	Plant species that can shade out algae.	x		x			Hard to predict outcomes, could have unintended consequences.
17.3	Addition of barley straw	May release substances that inhibit algal growth.	x		x			Ecology considers this a "home remedy". Hard to predict outcomes, could have unintended consequences.
18	Floating Wetlands	Use floating plants to remove P from water column.	x		x			Could interfere with lake uses.
19	Pump and treat system	Pump water from lake, treat to remove P, discharge treated water back into lake.	x	x	x			Likely to be expensive. Limited space on shoreline for treatment facility.
19.1	Chemical treatment	Pump lake water to shoreline treatment facility, add polymer to flocculate and remove P. Discharge treated water back into lake.	x	x	x			Likely to be expensive. Limited space on shoreline for treatment facility.
19.2	Constructed wetland	Pump lake water to wetland treatment system to remove P and algae. Discharge treated water back into lake.	x	x	x			Likely to be expensive. Treatment wetland would require large area. Limited space on shoreline.
20	Groundwater Interception	Place reactive material (such as dewatered floc from water treatment facility) around the perimeter of the lake (outside of the lake) to remove P and pathogens.	x	x	x			Would be very expensive and may be technically infeasible due to long shoreline and limited public land.
	Sources:							
	Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. Third Edition. Prepared for the North American Lake Management Society and the Terrene Institute in cooperation with the U.S. EPA. EPA 841-B-01-006. Madison, WI							
	Washington State Department of Ecology Lakes and Algae Management website, 2016. http://www.ecy.wa.gov/programs/wq/plants/algae/lakes/ControlOptions.html							